All About Laser Cutters
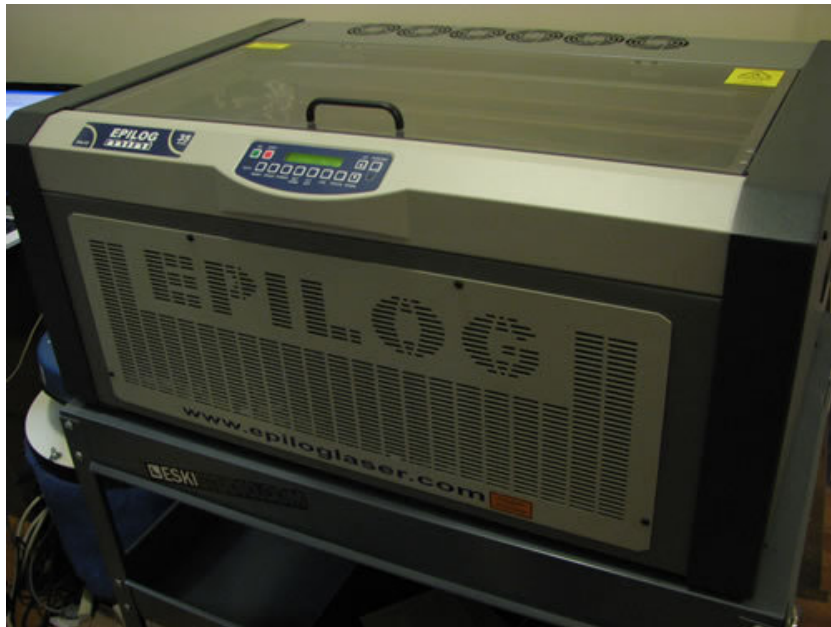
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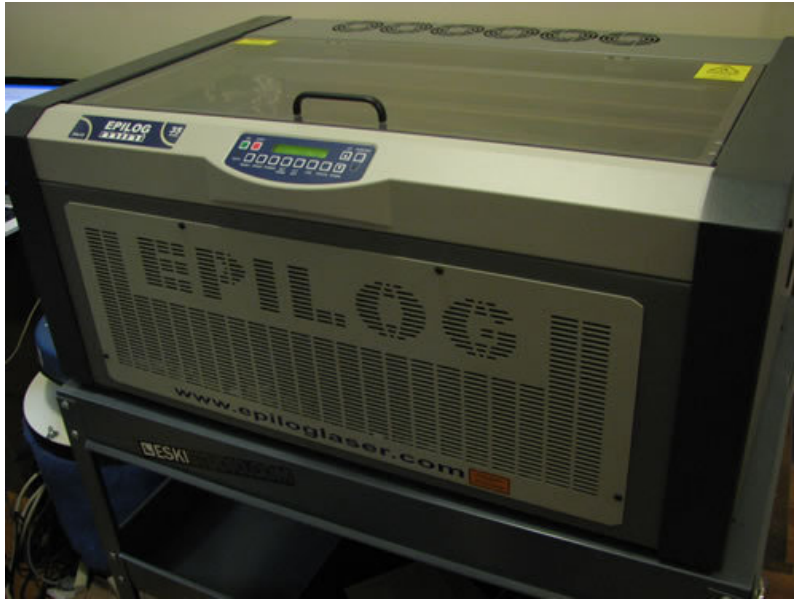

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Guide Contents

Overview

One of our favorite tools in the Adafruit factory is our laser cutter. A laser cutter is a tool made of an XY plotter with a bed about 12"x24" in size. Instead of a plotting pen, a laser beam is fired so that any shape can be cut out of a flat piece of plastic, wood, fabric, leather, etc. Even though laser cutters can only cut out of flat materials they are surprisingly versatile. By snapping together pieces and gluing or screwing parts together a full enclosure can be made.

For example, here is a laser-cut snap-together enclosure for the Raspberry Pi

They're also very fast and precise, and sometimes have the ability to 'raster' an image with remarkable results.

We wrote these tutorials up a few years ago, but they're still very useful for anyone with a laser cutter or thinking about adding a cutter to their workshop or hackerspace

Laser Equipment

Epilog Mini 24 (http://adafru.it/aXT) (Adafruit Laser uses the 35 watt model.)

Available from Epilog Laser (http://adafru.it/aXU)

Wattages: 30, 40, 50, and 60 watts. (updated 01/10)

Work area: 24 " x 12" (610 x 305 mm)

Z-stroke: Holds items up to 8" tall (203 mm)

Epilog Helix

Epilog Helix 24 (http://adafru.it/aXV)

Available from Epilog Laser (http://adafru.it/aXU)

Wattages: 30, 40, 50, 60, and 75 watts. (Updated 01/10)

Work area: 24 " x 18 " (610 x 457 mm)

Z-stroke: Holds items up to 11" tall (279 mm)

Epilog Mini/Helix Features

Included features: Red Dot Pointer, Air Assist, Auto Focus, Integrated Vector Grid & Vacuum Table, Radiance High Energy Optics

Options: Mini Floor Stand, Epilog Air Compressor, Rotary Attachment, Vector Pin Table

The laser can cut: Wood, plastic, acrylic, delrin, cloth, leather, matte board, melamine, paper, mylar, pressboard, rubber, wood veneer, fiberglass, cork, corian.

The laser can etch: Glass, coated metals, ceramic, marble, anodized aluminum, stainless steel, painted metals, tiles, wood, plastic, acrylic, delrin, cloth, leather, matte board, melamine, paper, mylar, pressboard, rubber, wood veneer, fiberglass, cork, corian.

These lasers *cannot* be used to cut or etch **PVC** or **vinyl** because chemicals are released that will destroy the optics and void the warranty. Some metals can be etched directly, but harder metals such as steel can only be marked using a spray called Cermark and available from LaserBits (http://adafru.it/aXW).

Notes:

Depending on many things you can get one of the Epilog Mini systems for as low as $15,000 or as high as $20,000 USD - it really depends on what dealer and where you are.

The Epilog Helix used by Ghost Marking was around $24,000, including the rotary attachment and ventilation system. Ghost Marking is in the San Fancisco area

Filtration System

Our filter system - Electrocorp Model RSU12-CCHR (http://adafru.it/aXX) (Electrocorp, while producing a fairly good laser filter, has terrible customer service and we'd go months without replacement insert filters so if we were to do this again, we'd probably try a different filter supplier.

Carbon cartridge/HEPA reverse flow Space saver air scrubber (data sheet, PDF (http://adafru.it/aXY)).

The fumes and dust from etched and cut material are toxic, you must have a filtration system in place! If you're going to cut or etch plastics or pretty much anything else you'll need a filter system

The cost of a filter system is about $2000 USD after shipping.

It might be possible to do a comparable DIY version, we're looking in to it. A rich source of such designs are from woodworking, who must regularly handle with a large amount of dust and

particulate matter generated by saws and other power tools. The woodworking filtration is generally down to the submicron level, at high CFM. But it also means that it is probably over spec'ed for laser use, and tends to be much louder than a dedicated low flow laser filter.

The Seattle, Washington Epilog rep uses a Purex filter (http://adafru.it/aXZ), model unknown. The pricing is "about $1750."

Same Seattle Epilog rep reports that with an attached filter the laser can be operated in any location without license or ventilation.

- Note: There are some disputes over whether it's necessary to have activated carbon in the filter path, and whether its use is to suppress odor, or to remove potential toxic fumes. In Purex's literature they didn't actively refer to the health benefits, only secondarily suggests that the Purex filter can potentially eliminate complaints by employee. I think if there is a legitimate health benefit they would have presented this argument much stronger. But make your own judgement.

Accessories

Duct hose- You'll need this to vent the laser to the filter. We use McMaster-Carr 53145K71 (http://adafru.it/aY0) - General Purpose Polypro/Rubber Duct Hose Black, 6" Id, 6-9/32" - 6 ft ($6.50 per foot).

Coupling increaser for duct hose - |McMaster-Carr 2013K57 (http://adafru.it/aY1) Galvanized Steel Round Duct Fitting 4" To 6" Diameter Increaser ($8.90 each).

Floor Stand

Steel cart - we use a 4633T1 Bolt-Together Steel Cart (http://adafru.it/aY2) with Open Shelves 500# Capacity, 32" Top Shelf Height, 36" X 24" Shelf from McMaster-Carr

Extra shelf - 36" L X 24" W Extra Shelf for 500 lb Capacity Light Duty Steel Cart (http://adafru.it/aY3) from McMaster-Carr

Extra drawer - 12" W X 18" D X 4" H Optional Drawer for Light Duty Steel Cart (http://adafru.it/aY4)

You can buy the $600 stand that Epilog sells, but we don't move the laser much and wanted storage as well. So, we went with this model available from McMaster-Carr. Its actually from Edsel so you can buy it elsewhere too. The extra shelf is installed upside down to hold plastic and other materials. The drawer is installed below that to hold small tools for the laser like the lens cleaning supplies bearing grease. The bottom holds tools, etc. We didn't install the casters, as they are not locking.

Fire Extinguishers

Fire extinguishers are an absolute necessity. Not only can the materials being etched catch fire, but the gases released can ignite as they pass through the laser beam. Epilog recommends CO_2 fire extinguishers because they do not contain chemicals that would be harmful to the mechanics or optics of the system. Class A extinguishers are for ordinary combustible materials such as paper, wood, cardboard, and most plastics (the stuff you're most likely lasering that could catch fire). CO_2 fire extinguishers don't work very well on class A fires because they may not be able to displace enough oxygen to put the fire out, causing it to re-ignite. Remember, Carbon Dioxide (CO_2) extinguishers are used for class B and C fires.

Epilog recommends a Halotron fire extinguisher or a multi-purpose dry chemical fire extinguisher. The Halotron extinguishers are more expensive than a dry chemical, but offer certain advantages should you ever need to use an extinguisher. The Halotron extinguisher discharges a clean, easily removable substance that is not harmful to the mechanics or wiring of the laser system. The dry chemical extinguisher discharges a sticky, corrosive powder that is very difficult to clean up.

That said, Halotron fire extinguishers have fallen out of favor for other "clean agent" fire extinguishers that are not "ozone depleting". These alternatives are even more expensive, which is why finding a used (re-certified) Halotron I extinguisher may be your best bet.

While CO_2 fire extinguishers have the benefit of being easily refilled, available used and inspected from licensed fire extinguisher service companies, and fun at parties - they are not recommended for protecting your laser.

Halotron I fire extinguishers start at about $120 for 2.5lb; $200 for 5lb. Halotron is considered a hazardous material, and will incur additional shipping charges if purchased online; it'd be best to check with a local distributor to see if they can beat the combined price!

Laser Supplies

These are optional supplies, often "consumables."

Cermark Metal Marking Spray

Shiny surfaces such as backs of iPods: use the Cermark laser etching spray (http://adafru.it/aY5) - we get ours from Laserbits (http://adafru.it/aXW). Spray the back of the iPod, wait 15-20 minutes then etch as usual. The power should be 100% and the speed should be the wattage of your laser, for us the speed is 35 since we have a 35W laser.

After the etch you just rub it off with a damp paper towel.

I've used the Cermark tape for people that are nervous about having their equipment sprayed and it works quite well. I've also purchased the paint on and it's much more economical and easy to apply. I've been using the LMM6000 purchased directly from Thermark. Buying at least the 250 from Thermark directly is about the same price but the 500 is cheaper from Laserbits. As with a lot of things, the more you buy the better price you get. [Aaron Haley]

Novus Acrylic Polish

Good when working with acrylic: will buff and shine! Sort of like toothpaste, comes in bottles. Apply with rag (has directions on bottle).

Available from McMaster-Carr and some hardware stores.

Fine scratch remover (8 oz) (http://adafru.it/aY6)

Heavy scratch remover (8 oz) (http://adafru.it/aY7)

Maintenance

Up-keeping your laser

Laser cutters are very expensive piece of equipment - chances are you spent over $5,000 on yours (we spent $15k!) which means its important to keep the machine in good condition. There is nothing worse than having a multi-thousand dollar machine destroyed because of a few minutes' negligence.

You don't even need to do that much, to keep everything in top condition!

Always

Never let the machine run unattended especially when its cutting!

Acrylic is extremely flammable and it goes without saying that wood, paper, mylar, delrin and other materials are as well.

We know of two three four **five** people who have had to essentially replace their laser cutting machine because it caught on fire unattended. One person had their entire shop burned down because they cut acrylic and left it.

Never let the machine run unattended especially when its cutting!

Its simply not worth it! Adafruit has never had a fire that damaged the machine because we keep an eye on it and make sure someone is within 3 feet at all times. There have been times when material caught but we quickly put it out.

Never let the machine run unattended especially when its cutting!

Daily (after 8 hours of lasering)

Every day, or after 8 hours of solid laser cutting, be sure to check the lens and clean it if necessary. The top lens and mirror are right above the laser beam which means they are exposed to a lot of dirt, fumes, smoke and debris. If the lens gets dirty a few things happen.

1. The laser won't cut nearly as well, requiring lower speeds or higher power, to cut.
2. The laser won't engrave nearly as well, with uneven results and blurry images.
3. Eventually, the dirt on the lens/mirror can catch on fire and melt the lens/mirror permanently damaging it.

You can keep the lens and mirror clean by removing it and gently cleaning both sides using a q-tip or (better yet) lens paper. Use the fluid that comes with the machine, do not use anything like alcohol or acetone or other cleaner. Only use the lens cleaner fluid provided!

Weekly (after 40 hours of lasering)

We find that if we keep the machine cleaned on the inside the only other maintenance we need to do is on the filter. The filter we have (the Electrocorp RSU-CCHR12 now supported by AllerAir) has multiple stages and each one has some maintenance needs.

Once a week (sometimes more or less, depending on how often its used and what we're cutting/engraving) we have to change the inner 'pad' pre-filter and clean out the foam dust-collector. Here are some hints that will indicate that you need to replace the filter.

1. Smoke is collecting in the laser bay, not being sucked away.
2. There are small fire/flares in the bay.
3. There is more odor emanating from the machine.
4. The filter is dirty on both sides.

To replace the inner pad filter and the foam dust collector, open up the machine.

Inside you will see the inner filtration assembly. On the inside of the metal mess is a foam dust collector filter. The foam catches the big dust particles. We just rinse this out in the sink and dry it out before replacing.

On the outside is a wrapped pad pre-filter.

When the filter is used up, its dirty on both sides (it will always be dirtier on the inside, of course).

Normally it should be bright white. You can remove the cardboard holder to see the difference.

You can simply buy new pre-filters from your filter-seller and wrap them around. Ours has double sided tape (or velcro) to keep it in place.

6-12 months

The pre-filter and HEPA do their best to get rid of particle matter. However, there is also odors that come from cutting, especially plastics. For this reason, the Electrocorp also has 20 lbs of carbon granules. These absorb the nasty smell that is made from plastic cutting. Eventually, however, the charcoal gets 'full' and no longer absorbs fumes.

Here are some hints that will indicate that you need to replace the charcoal:

1. The odor of burning plastic/wood is very strong.

2. Smoke is being sucked away just fine.
3. The filter is clean and the problem doesn't go away.
4. The charcoal smells of fumes when the machine is off.

You can buy charcoal granules from the company and replace the machine. First pour out and throw out the old charcoal. Then pour in cup-fulls of fresh charcoal while tamping down with a rubber mallet or a wooden dowel to make sure you have packed charcoal. While the machine manual implies there is '20 lbs' of charcoal in there, we bought a '30 lb box' and it filled it twice. YMMV

~Yearly

Finally, the only thing left that can be replaced in the machine is the HEPA filter, which does the

fine-size filtration. Because its expensive ($200 or so) you'll want to make sure to change the prefilters as soon as they get dirty or you will end up clogging the HEPA prematurely.

1. Smoke is collecting in the laser bay, not being sucked away.
2. There are small fire/flares in the bay.
3. There is more odor emanating from the machine.
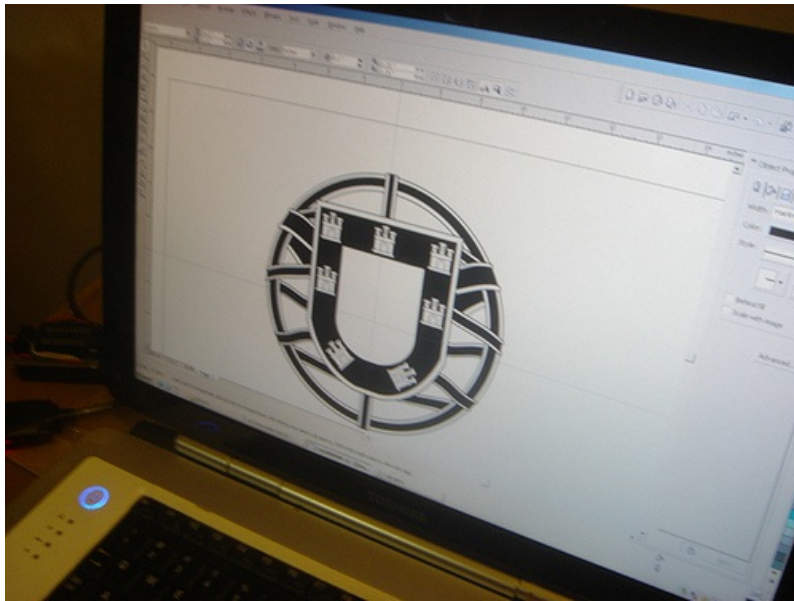4. The filter is clean/replaced.

Computer & Software Setup

Hardware

Either a windows computer running Windows XP or Windows 7 (suggested) or an Intel Mac running Parallels or Bootcamp.

Must have USB or Ethernet (Ethernet is faster) in order to connect to laser cutter.

Don't forgot to use a crossover Ethernet cable to connect to the printer on a PC! (Macs automatically crossover the cable).

Software

Corel Draw

There are other applications that work with the Epliog laser (the laser is basically a "printer") but we use what seems to be most supported, Corel Draw. The retail / download version costs about $379. If you're using a Mac (Intel based) you can use Parallels, that's likely the set up we'll end up with. A Macbook pro with Mac versions of design tools (Adobe Illustrator) and just Corel to "print" to the laser when needed. Any modern PC should run Corel Draw fine, we've found that it's usually easier and better to edit graphics on a Mac and use the PC for Corel Draw and lasering.

Bitmap to Vector converter

Since the laser has 600+ DPI precision, vector images look the best. You will probably want to

convert your files from bitmap to vector. Here are some suggetsions:

1. About.com (http://adafru.it/aY8) a full list of all options at about.com
2. Silhouette (http://adafru.it/aY9) also called "ArtLine" Mac or Windows

Settings

Acrylic

For engraving, 100% speed and 55% (600dpi), 65% (400dpi) or 75% power (300dpi) â€" Epilog Manual.

For cutting, use 5000 ppi frequency. Remove the top layer of paper.

REMEMBER THAT ACRYLIC IS FLAMMABLE - DO NOT LEAVE THE LASER UNATTENDED!

Material	35W Cut	Notes
Clear 1/16" (0.062")	100% power, 20% speed	A clean cut on paperbacked acrylic, higher speed may be OK
Clear 1/8" (0.125")	100% power, 12% speed	From the Epilog Manual
Clear 1/4" (0.25")	100% power, 4% speed	From the Epilog Manual

Anodized Aluminum

	35W etch	45W etch	Notes
300 DPI	100% power, 100% speed	90% power, 100% speed	From the Epilog Manual
400 DPI	90% power, 100% speed	80% power, 100% speed	From the Epilog Manual
600 DPI	80% power, 100% speed	70% power, 100% speed	From the Epilog Manual

Moleskine's (pocket notebooks)

Moleskine covers contain PVC, and should not be engraved on a laser cutter - they contain harmful toxins that can damage you & the laser!

iPods

Anodized iPods (Mini, Nano 2G and Shuffle 2G) use standard Anodized Aluminum settings.

Other iPods with stainless steel backs should be etched with Cermark spray (Get more info under Supplies.)

Leatherman Multitool

For anodized Multitools, use standard Anodized Aluminum settings.

Cell phones

For phones that are metallized (such as this Motorola RAZR) use standard Anodized Aluminum settings.
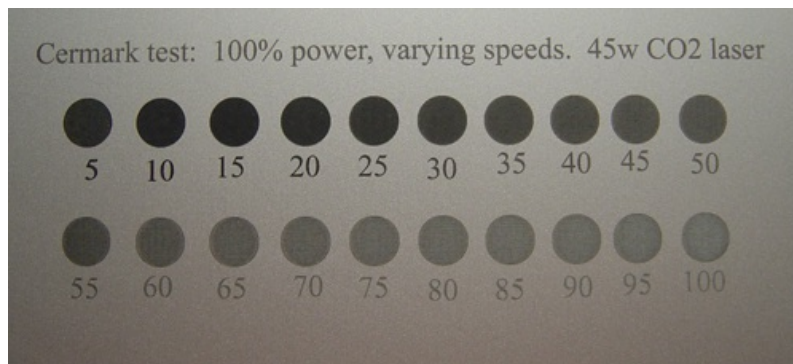
[Need to do larger phone survey of models! Please add data!]

Laptops

Please help add more!!

Aluminum/Metal Apple PowerBook/MacBooks

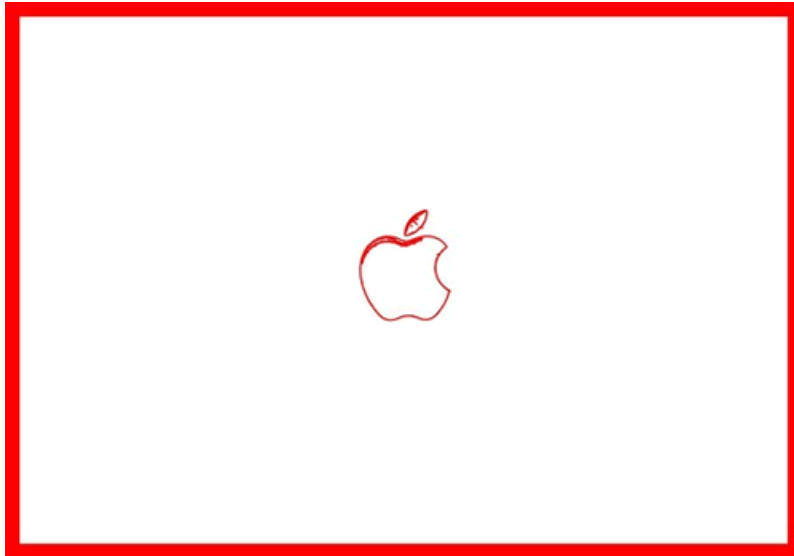The most popular device to etch! 100% speed and 100% power on 35W laser.

Black 'Cermark' etching on Aluminum/Metal Apple PowerBook/MacBooks
Speed and Power level test for Cermark spray on brushed aluminum:

On a 45w Epilog Helix a setting of 100% power and 15% speed achieved the darkest and most uniform black using Cermark spray on the prushed aluminum side panel from a G5 tower.

Templates

Powerbook 12" (http://adafru.it/aYa) , 15" (http://adafru.it/aYb) , 17" (http://adafru.it/aYc) (AI - Illustrator files @ Instructables (http://adafru.it/aH8) & tutorial (http://adafru.it/aYd) - Thanks Saul!)

Plastic MacBook (Black)

Some banding appears from the plastic case molding process. 100% speeed 50% power on a 35W laser has worked out for us so far. (30% is much too low.)

Plastic Apple iBook and white MacBook

So far, these cannot be (easily) etched or marked because the case is made of polycarbonate which turns yellow and chars when laser cut or etched! We've attempted some low power and multi-pass etching, it's promising but so far the demand is pretty low.
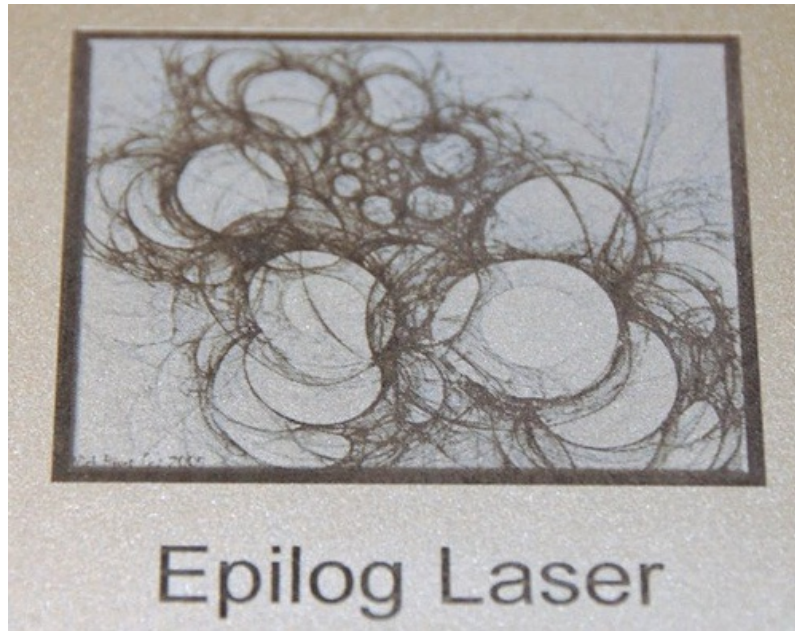
It might be worth trying masking tape (http://adafru.it/aYe) [My sales rep recommended it for solving those kinds of problems, but I don't have an iBook/MacBook on which to test the theory. Bill]

Sadly the wavelength from CO2 Lasers make it really difficult and almost impossible to engrave on polycarbonate. The only solution (so far) to engrave this material is to use a YAG/Fiber laser. A great example of this technology used on a white MacBook is on the following link to the Epilog's website.

http://www.epiloglaser.com/sc_macbook.htm (http://adafru.it/aYf)

Toshiba Tecra 9000

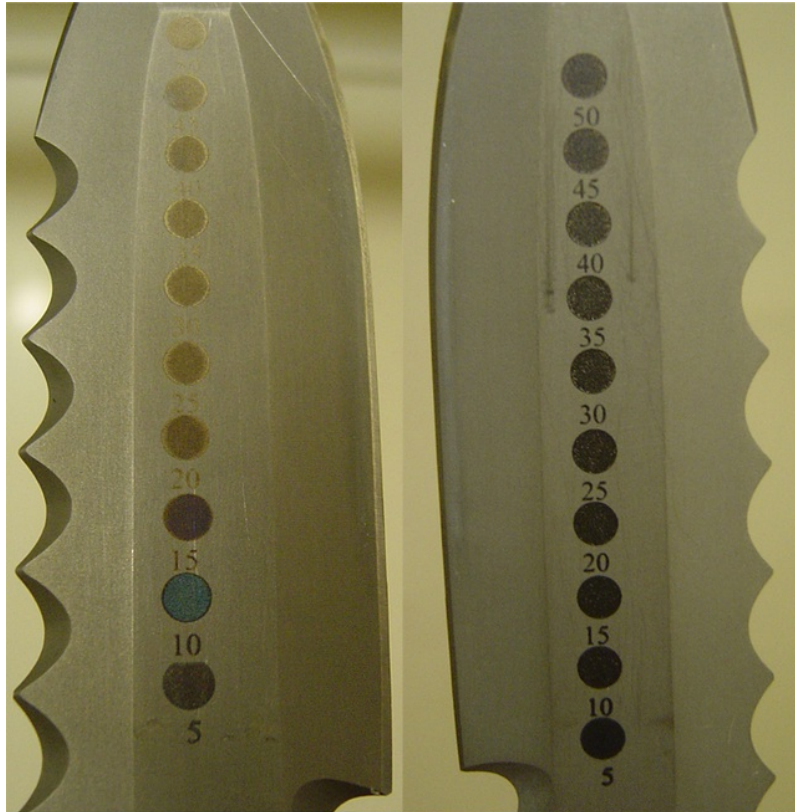With metallic (aluminum?) cover. Marked with CerMark spray.

External Hard Drive

7% power, 46% speed (75 Watt helix) works wonders on a Seagate Goflex hard drive.

Titanium metal etching/marking

Having just completed testing of both bare etching and Cermark marking, I was rather surprised with the results. It appears that titanium will mark under just the power of the laser alone, and the color will vary according to the amount of energy utilized (in this case as a factor of power * speed). Here is an image of etching titanium bare, and with Cermark:

45w CO2 laser only,
100% power, varying speed

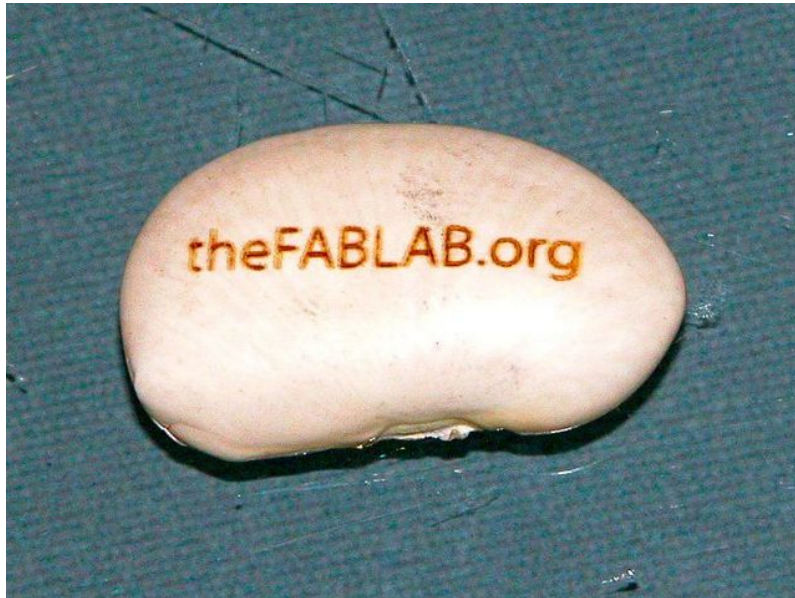*45w CO2 laser on Cermark*
100% power, varying speed

Glossy Tile Etching

After giving this a shot, I found that a speed of 92 and a power of 80 works pretty dang well (I used a 75 watt helix so your milage may vary). Home made coasters!

Lima Beans

Using a 35W Epilog mini, 60% power 100% speed. The beans should be placed in some sort of soft holding bed both to even them out as well as to stop the air assist from moving them. We used lentils and eventually made a jig with cardstock to mass produce the beans.

Laser Providers

Here is a list of all the places we know that specialize in gadget & laptop tattoos!

Inclusion in this list does not imply recommendation by Adafruit. Buyer beware!

Some shops whose main business is 'retail' technology (laptop/gadget) tattooing:

- Public Art International (http://adafru.it/aYg) : Rotterdam (The Netherlands) based company offering laser etching on laptops and iPods, dogtag engraving, acrylic lamp designs, graffiti stencils, custom Arduino projects.
- ETCHamac (http://adafru.it/aYh) : custom laser etching for macs and iPods, using an only flash design system. Mailorder or walk-ins. Located in Peoria, AZ. Offers Cermark spray. iPods are ~$50 and laptops are $50-$200 by "quarter."
- Technology Tattoo (http://adafru.it/aYi) : In Minneapolis, by appointment only. No other information.
- RazorLAB Ltd (http://adafru.it/aYj) : London based company offering laser etching on laptops, iPods, etc.
- Scott Campbell Tattoo (http://adafru.it/aYk) : Brooklyn, NY tattoo studio with laser cutter for laptops. $200 for 'portfolio design', $300 for custom design. (Not much more info). (http://adafru.it/aYk)
- iStyle Custom (http://adafru.it/aYl) : LA shop. ~$30 for small devices, ~$100 for large ones.
- TATUIT (http://adafru.it/aYm) : Serving Portland, OR and Vancouver, WA - Located in Portland, OR. Objectifying Art on cellphones, iPods, mp3 players, laptops and more.
- Powerbook Laser Engraving (http://adafru.it/aYn) : Exactly what it sounds like, $100 for laptops, in Colorado.
- engravee (http://adafru.it/aYo) : Boston MA (back bay). By appointment only, prices starting out at $30 for cells+iPods, $80-$100 for laptops.
- engrave (http://adafru.it/aYp) : Located in Portland OR. Not accepting laptop/gadget engraving appointments at this time.
- Tech-Tattoos (http://adafru.it/aYq) : Offering laser etching for your electronics by appointment in Toledo, OH.
- Austin Laser Art (http://adafru.it/aYr) : Art, Technology, Craft, and Traditional Laser Engraving in Austin, Texas.
- CADD Graphics (http://adafru.it/aYs) : Specializes in firearms engraving specifically high powered rifes (you may ship guns as that they are a Class 01 FFL as licensed by ATF), electronics marking for theft loss and inventory purposes as well as wood, marble and granite engraving/cutting.

Other Shops

- Big Blue Saw (http://adafru.it/aYt) : Offers a CAD design tool and online ordering for laser and waterjet cut parts.

- Pololu (http://adafru.it/aYu) : Custom laser cutting from $25.
- Ponoko (http://adafru.it/aYv) : A place where you can make and sell laser cut ideas to the world.
- 2dparts (http://adafru.it/aYw) : Fast. Cheap. Precise. Laser cut and Waterjet Parts.
- NextFab Studio (http://adafru.it/aYx) : Trotec classes and contract work. NextFab is a MakerSpace in Philadelphia.

Links & Resources

More Resources

- Forums on ladyada.net (http://adafru.it/forums) for Adafruit Laser and friends.
- Hundreds of 'laser cutter applications' from Synrad (http://adafru.it/aYz) mostly marking.
- George T. Schmidt (http://adafru.it/aYA) Maker of marking lasers, only sells Nd:YAG diode pumped lasers. Their systems run anywhere from $80,000+. Used by big companies like GM.

Other lasers

- A fellow's laser cutting experiences (with a Universal) (http://adafru.it/aYB)